

Medicine, Critical Science and the Real World

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A MAN WOULD HAVE to be a fool to buy a map with just one road printed on it. Assuming that it led to his intended destination in the first place, it may not be the best way to go, he may bypass many places where he might wish to stop, and he has no way of correcting himself should he become lost.

This is precisely what happens when "basic" research is sacrificed for "applied" research, or when an attempt is made to impose a schedule on discovery and application.^{1,2} Science depends too heavily on serendipity and the astute observation and flash of insight.^{3,4} The concept that science can be programmed is derived from industrial "R&D" (research and development), which with a few outstanding exceptions is heavy on the "D" and light on the "R". Basic science is by definition investigation into areas with no immediately foreseeable application.

This is the mode of science which fills in the uncharted white spaces of our metaphorical map, the mode on which we fall back when confronted with the unexpected and from which come so many fortuitous observations and unanticipated applications, and an understanding of mechanisms. In short, it is basic science that pieces together a world picture. Without some comprehension of the totality, some perspective within which to place each new thrust of applied and directed science, we are doomed to constant repetition of the past excesses of technology: smog and the automobile, microbial resistance and antibiotics, sarcomas and radium watch dials, soil and water

degradation and strip mining, phocomelia and thalidomide.

Obviously basic science does not have a ready answer for every question as it arises, but clearly such answers are much closer when workers have been allowed to extend their investigations into areas that appeared improbable of application before the question arose. One example, drawn from outside medicine and chosen for its lack of glamour, is the large body of work on food chains and energy budgets in terrestrial and aquatic ecosystems. How many graduate students and junior faculty spent months wading in muddy marshes or sweltering in abandoned cornfields to watch squirrels eating seeds and grebes catching fish may never be known. The concepts that developed from such tedious and esoteric work, however, have proven enormously useful in our understanding of the biosphere, and have proven essential in the development of ocean resources, agriculture and theoretical biology. They are now finding their way into urban planning. A striking example closer to home for most of us was the basic research in immunology and virology which led to the development of a poliomyelitis vaccine.

Basic science and applied science are the two commonly accepted modes of research, the latter being associated with technology. For hundreds of years, until the emerging European middle class discovered the enormous profit to be realized by combining their hobby of science with their business of industrialization, science and technology scarcely spoke to one another and followed entirely separate historical paths. Lavoisier, Watt and Pasteur showed that directed scientific research in the service of technology could prove immensely productive, and so developed the mode

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of applied science. Unfortunately, the same law of data processing governs applied science: garbage in/garbage out. The quality of the work is independent of the worthiness of the goal and the quality of the assumptions and data. We are treated to the spectacle of millions of dollars spent to develop redundant drugs to circumvent patents while other areas of biomedical science are starved for funds.

In the broad perspective of the history of science, the emergence of a new mode* of science is an exceedingly uncommon event. It is very exciting that this appears to be happening in our time. The new mode is named "critical science" by its principal analyst, Dr. Jerry Ravetz, of the University of Leeds (England), who describes it as a new approach which critically evaluates and analyzes the impact of technological developments within the context of the real world (not the engineer's world of simplifying assumptions), and which draws primarily on basic science and collaborative critical research to predict, document and correct physical and human problems of technological origin.⁵

Credit for the first sustained organized effort in critical science goes to Dr. Barry Commoner, of Washington University in St. Louis, whose work dates to the rise in public concern over radioactive fallout in the 1950's.⁶ He has worked since then through the American Association for the Advancement of Science, the Scientist's Institute for Public Information, the St. Louis Committee for Environmental Information and his Center for the Biology of Natural Systems. His work has focused mostly on environmental problems and he has assembled a young and bright community of researchers around him.⁷

The one essential tool of critical science is knowledge, in the sense of both data and unifying concepts. To this end it requires the highest quality of original research and thoroughgoing comprehension of many scientific disciplines. It stands to become a powerful integrative force in the scientific world, a confluence of specialties without amalgamation into a bland and superficial generalism.

In our own province of medicine, which transects so many other disciplines, such a mode of science is also evident, perhaps most clearly demonstrated in the little-heralded emergence of

a newly coherent field of study which treats ecological factors in human settlements pertinent to health. This has been variously called ecological medicine, medical ecology, human ecology, environmental medicine and—the term that I prefer because it allows for precise definition with a minimum of false connotations—enviromic medicine.^{8,9}

This is an inauspicious time to found a new discipline. René Dubos pointed out that "the requirements of human ecology for new kinds of research facilities and for a change in intellectual opinion will provide a ready excuse for neglect . . . this science will develop only if society recognizes that ecological knowledge is essential to its welfare . . ." ¹⁰ Not the least of many dangers that this new discipline faces is the bandwagon effect that has plagued the ecology movement since its early rise in public attention and which is also evident today in cancer research. On the other hand, encouraging signs include the prospect of healthy support for basic and critical research in the effects of hazardous substances. The National Institute of Environmental Health Sciences, for example, is supporting a series of Environmental Science Centers at academic centers.

We can only wish that this bold new discipline will fulfill its promise as a valuable study in its own right and as a model for critical science in medicine. Bertrand Russell in 1924 well characterized the impact of a scientific discipline: "A science may affect human life in two different ways . . . without altering men's passions or their general outlook, it may increase their power of gratifying their desires. On the other hand, it may operate through an effect upon the imaginative conception of the world, the theology or philosophy which is accepted in practice by energetic men."

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*A mode is a fundamentally different approach to acquiring or applying knowledge, as opposed to a discipline, a practice or a topic.